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GB 2232332 A GB 1558062 A GB 1530621 A
EP 0471096 A1 US 5228071 A

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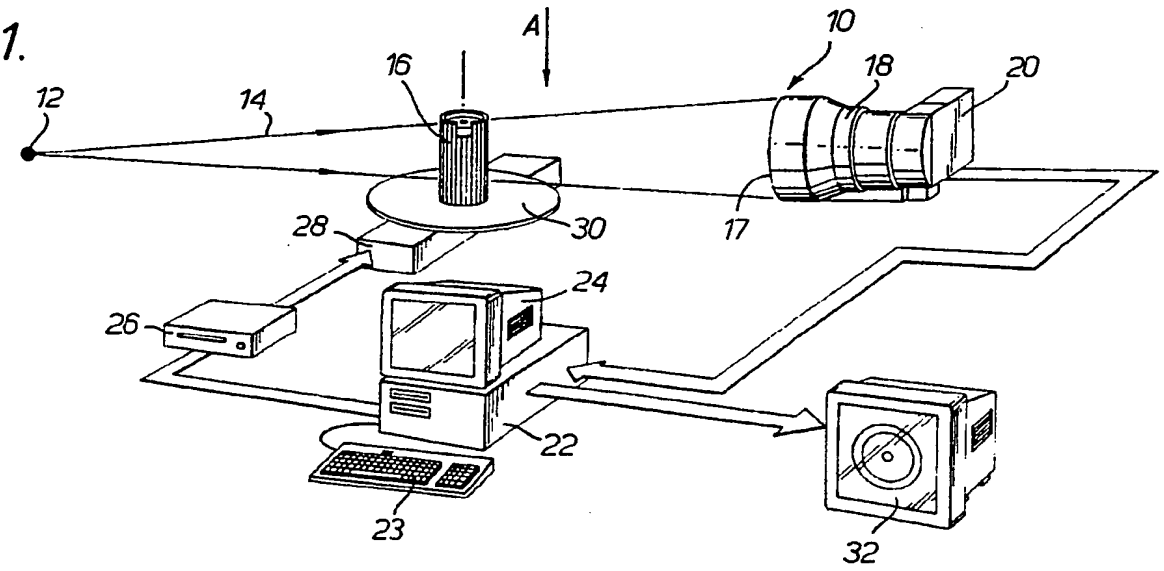
(54) Computed tomography

(57) A computed tomography apparatus including a source (12) of radiation, a turntable (30) to support an object (16), and a fluorescent screen and a video camera, or an image intensifier (17, 18) and a camera (20), to detect the transmitted radiation, is modified by the incorporation of a linear drive means (28) to move the object (16) laterally into different positions at each different angular orientation. The lateral movements are such as to move the image on the input screen (17) a random number of pixels of the digitised video signal. The digitised signals are corrected to allow for the lateral displacement of the image, before being processed to calculate a tomographic image. Artefacts due to coherent noise, which would give ring patterns on the reconstructed tomographic images, are hence suppressed.

Fig.1.



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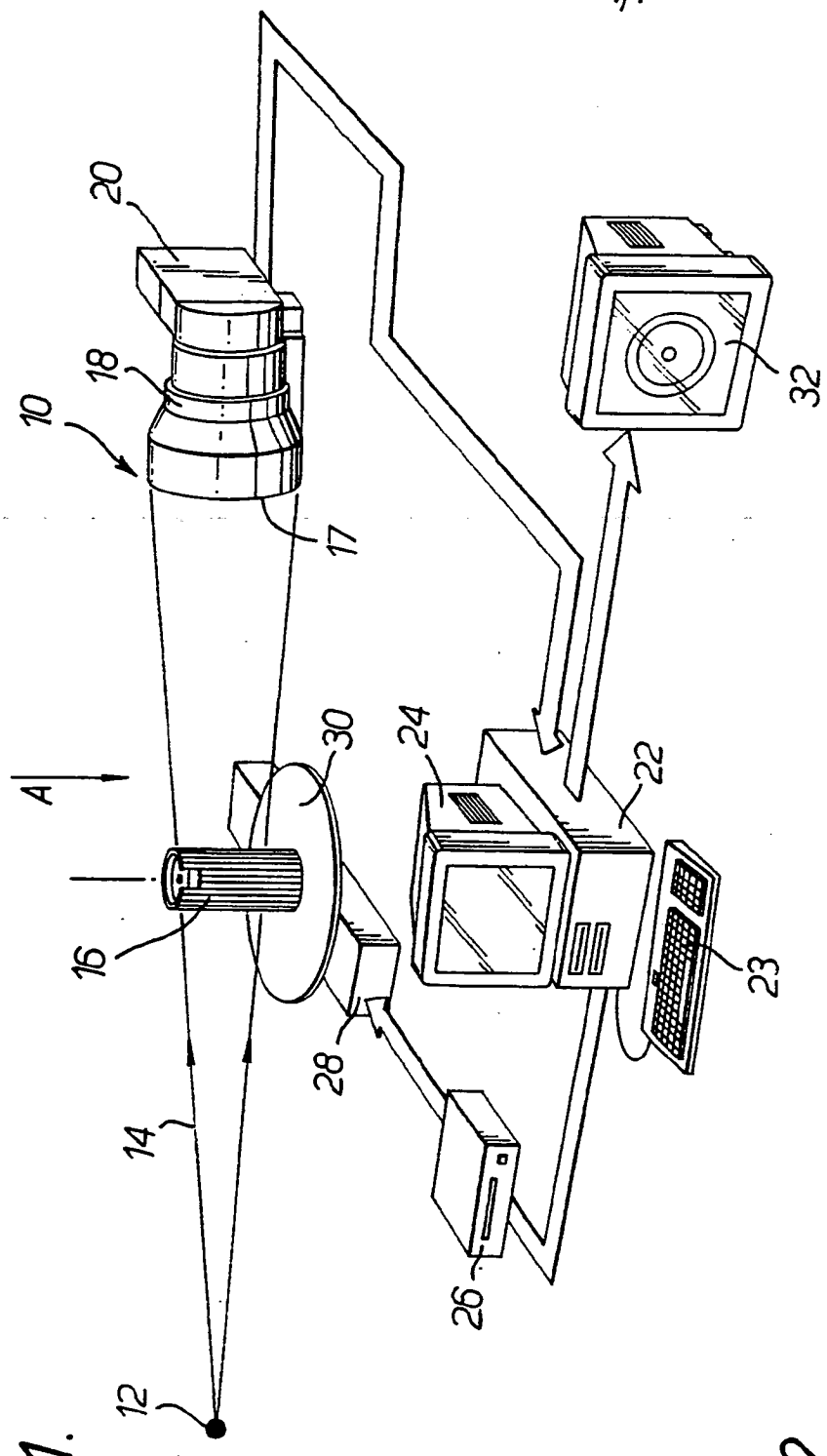

Fig.1.

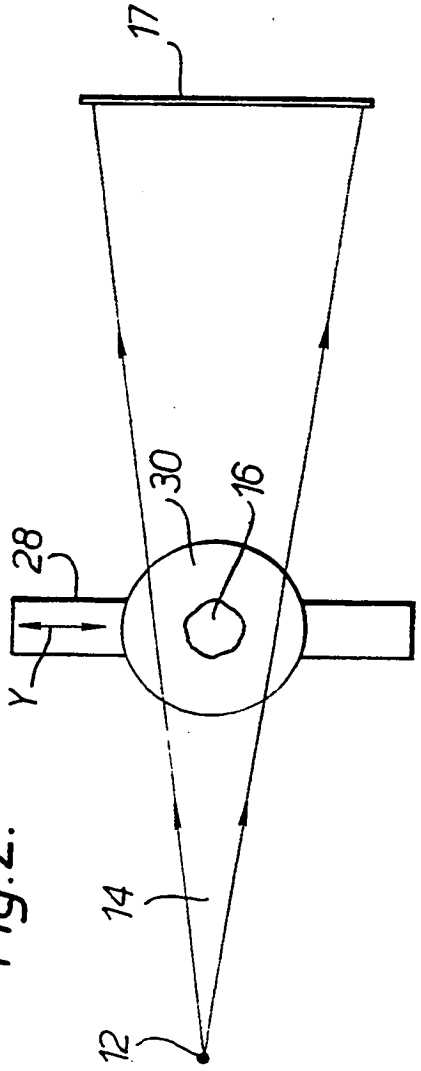

Fig.2.

Computed Tomography

This invention relates to computed tomography, and in particular to a method and an apparatus for performing computed tomography using a linear or a two-dimensional array of detectors.

Computed tomography (CT) is a method by which a cross-sectional view of an object can be generated from measurements of the intensity of a beam of penetrating radiation, for example X-rays, after the beam has passed along several paths in the plane of the desired cross-section. If a fluorescent screen is used as the detector, and the resulting visible image is viewed by a television camera, as described for example in IEEE Trans. on Nuclear Science, Vol. NS-26, No 2, April 1979 pp. 2707-2709, and IEEE Trans. on Nuclear Science, Vol. 33, No 1, February 1986 pp. 527-530, then it is possible to obtain multiple cross-sectional views (slices) from data accumulated during a single rotation of the object relative to the source and detector. However images produced by means of such detectors suffer from a certain amount of coherent noise, due to small variations in sensitivity and due to noise from the digitising process, which causes ring-shaped artefacts in the computed images.

According to the present invention there is provided a method of obtaining, by computed tomography, an image of an object, the method comprising irradiating the object with a beam of penetrating radiation, detecting the transmitted radiation with a linear array or a two-dimensional array of detectors, rotating the object relative to the beam about an axis of rotation, and from signals representing the detected radiation for a plurality of different rotational orientations of the

object relative to the beam calculating an image of the object, wherein the method also comprises displacing the object linearly relative to the beam along a line parallel to that of the linear detector array, or in a plane parallel to that of the two dimensional detector array, into different positions for different said rotational orientations, and taking the different positions into account in calculating the image.

The movements, whether of rotation or of displacement, of the object relative to the beam may be brought about by moving the source of the radiation and the detectors, or preferably by moving just the object. The displacements are linear and so do not change the orientation of the axis of rotation. Displacement of the object relative to the beam changes the position in the array of detectors at which radiation transmitted through any particular point in the object is detected. Hence the artefacts due to coherent noise are suppressed.

Preferably the object is displaced relative to the beam into a different position for each successive said rotational orientation. Each displacement may be such that the position in the array at which the radiation transmitted through any particular point in the object is detected is changed by an integral number of detectors. In a preferred method, the said position in the array changes within a range of for example, twelve or ten detectors either side of an initial position; successive positions may be chosen in accordance with a sequence of random or pseudo-random numbers. Where the array is two-dimensional and includes an array of detecting pixels aligned parallel to two orthogonal axes, the displacements are preferably all parallel to one of those axes.

The invention also provides an apparatus for use in obtaining, by computed tomography, an image of an object, the apparatus comprising means for supporting an object in a beam of penetrating radiation, a linear or a two-dimensional array of detectors onto which the transmitted radiation is incident, and means responsive to signals from the detector array for calculating a computed tomographic image of the object, the support means comprising means to rotate the object relative to the beam about an axis of rotation into a plurality of different rotational orientations, and means to displace the object linearly relative to the beam along a line parallel to that of the linear array, or in a plane parallel to that of the two-dimensional array, into different positions for different rotational orientations.

The radiation might be for example X-rays or γ-rays. The detector array may for example comprise a fluorescent screen in combination with a low-light-level video camera, or an image intensifier and a video camera. In each of these cases analogue signals representing the lines of the camera image are digitised, typically into 512 or 768 pixels per line, and so the array is constituted by the pixels forming the camera image. Alternatively the detector may include a camera which provides a digital output directly, for example a high-resolution CCD camera.

The invention will now be further described, by way of example only, and with reference to the accompanying drawings in which:

Figure 1 shows a perspective view of a computed tomography apparatus; and

Figure 2 shows a diagrammatic plan view in the direction of arrow A of Figure 1.

Referring to Figure 1 a computed tomography apparatus 10 includes an X-ray source 12 with a 1 mm diameter focal spot which generates a divergent beam 14 of X-rays. The beam 14 passes through an object 16 (of which one or more tomographic images are to be obtained) and the beam 14 is then incident on an input screen 17 at the front face of an image intensifier 18 behind which is a video camera 20. The analogue video signal from the camera 20 is supplied to a computer 22. Operation of the apparatus 10 is controlled by means of a keyboard 23 and a monitor 24 linked to the computer 22. In accordance with instructions from an operator, one or more lines from the video signal are selected, and are digitised by an analogue-to-digital converter which converts the entire line at once. The computer 22 is connected, via an interface unit 26 to a stepper-motor driven linear motion stage 28 on which is a stepper-motor driven turntable 30; and also to an image display monitor 32.

The apparatus 10, with the exception of the linear motion stage 28, is of known type. If the linear motion stage 28 were omitted then the apparatus would operate in a known manner as follows: in accordance with instructions from the operator the turntable 30 is energised to rotate the object 16, typically through 180°, in equal steps of for example 1° or ½°. At each angular orientation of the object 16 the (or each) selected line from the video signal is digitised by the analogue-to-digital converter in the computer 22. The line is hence represented as a sequence of digital values, usually 512, each representing the intensity of the transmitted X-rays; the portions into which the line is divided are referred to as pixels. The digitised

representations of the selected line for all the different orientations of the object 16 are then processed by a standard algorithm (for example filtered back projection) so as to calculate a tomographic image showing a cross-sectional view of the object 16 in the plane defined by the X-ray source 12 and the selected line on the input screen 17. The calculated image is then displayed on the monitor 32. If data are recorded for more than one such selected line, then more than one such tomographic image can be calculated.

Referring also to Figure 2, this shows a diagrammatic plan view of the X-ray source 12, the object 16, and the input screen 17 of the image intensifier 18. In use of the apparatus 10 the linear motion stage 28 is activated to move the turntable 30, and so the object 16, into a different lateral position at each angular orientation, before the signal from the video camera 20 is digitised. The stage 28 is arranged to displace the object 16 horizontally parallel to the input screen 17, as indicated by arrow Y in Figure 2, and so parallel to the lines in the image on the screen 17 along which the video camera 20 scans. The displacements are controlled by the computer 22, and correspond to a series of random numbers such that each displacement moves the image of the object 16 on the screen 17 by a number of pixels, ranging between about ten pixels to the right and ten pixels to the left of the mean position.

The computer corrects the digitised representation of each line to correct for the number of pixels that the image was displaced, before the digitised signals are processed to calculate the tomographic image in the standard way. This provides better quality tomographic images than in the absence of the lateral movements, because artefacts due to coherent noise in the detector

(the input screen 17, the image intensifier 18 and the camera 20), or in the analogue-to-digital converter, are suppressed. If the displacement corresponds to a non-integral number of pixels this correction step will involve interpolation.

It will be appreciated that the invention is applicable to a wide range of different computed tomography apparatuses. The detector might for example be a single linear array of photodiodes with a phosphor coating; or it might be an image intensifier combined with a video camera providing a digital output. The lateral displacements might correspond to a smaller or a larger number of pixels (for example plus or minus five, or plus or minus twelve); and might correspond to a pseudo-random series instead of a random series. The radiation source might be an industrial X-ray source, or a microfocal X-ray source, or a source of other radiation such as gamma rays.

Claims

1. A method of obtaining, by computed tomography, an image of an object, the method comprising irradiating the object with a beam of penetrating radiation, detecting the transmitted radiation with a linear array or a two-dimensional array of detectors, rotating the object relative to the beam about an axis of rotation, and from signals representing the detected radiation for a plurality of different rotational orientations of the object relative to the beam calculating an image of the object, wherein the method also comprises displacing the object linearly relative to the beam along a line parallel to that of the linear detector array, or in a plane parallel to that of the two dimensional detector array, into different positions for different said rotational orientations, and taking the different positions into account in calculating the image.

2. A method as claimed in Claim 1 wherein the object is displaced relative to the beam into a different position for each successive said rotational orientation.

3. A method as claimed in Claim 1 or Claim 2 wherein each displacement is such that the position in the array at which the radiation transmitted through any particular point in the object is detected is changed by an integral number of detectors.

4. An apparatus for use in obtaining, by computed tomography, an image of an object, the apparatus comprising means for supporting an object in a beam of penetrating radiation, a linear or a two-dimensional array of detectors onto which the transmitted radiation is incident, and means responsive to signals from the detector array for calculating a computed tomographic

to rotate the object relative to the beam about an axis of rotation into a plurality of different rotational orientations, and means to displace the object linearly relative to the beam along a line parallel to that of the linear array, or in a plane parallel to that of the two-dimensional array, into different positions for different rotational orientations.

5. A method of obtaining, by computed tomography, an image of an object, substantially as hereinbefore described with reference to, and as shown in, the accompanying drawings.

6. An apparatus for obtaining, by computed tomography, an image of an object, substantially as hereinbefore described with reference to, and as shown in, the accompanying drawings.

Patents Act 1977 Examiner's report to the Comptroller under Section 17 (The Search report) -9-	Application number GB 9401693.8
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Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii)	Documents considered relevant following a search in respect of Claims :- 1-6

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Category	Identity of document and relevant passages		Relevant to claim(s)
X	GB 2232332 A	(GEC)	1-4
X	GB 1558062	(EMI)	4
X	GB 1530621	(EMI)	1-4
X	EP 0471096 A1	(TOSHIBA)	1-4
X	US 5228071	(KAMATA)	4

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